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STATE OF ILLINOIS

ENVIRONMENTAL PROTECTION AGENCY

DIVISION OF LAND/NOISE POLLUTION CONTROL

AQUIFERS OF ILLINOIS: UNDERGROUND SOURCES OF DRINKING WATER AND NON-DRINKING WATER

by

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GROUNDWATER GEOLOGY

Every day a large amount of ground water is pumped from aquifers for municipal and domestic supplies, and industrial and agricultural uses. It is estimated that 940 mgd of groundwater was withdrawn from the aquifers during the late 1970's (Piskin et al., 1981). About 38 percent of the State population depends on ground water (U.S. EPA, 1977). Dependence on ground water is much higher in rural areas, between 85 and 100 percent (Withers et al., 1981).

Geological conditions and rock types control the occurrence, storage, availability, flow, and natural quality of ground water. The permeable formations, which store water and allow it to flow into wells, are called aquifers. Rock with relatively low permeability acts as a confining layer by preventing a significant groundwater movement between aquifers. Thus, in order to understand groundwater conditions, the distribution of aquifers and confining layers in the State must be known.

The rocks of Illinois are shown in Plates 2 and 3. The aquifers are listed in Table 1. The rocks which are identified as aquifers are marked accordingly. This identification was made by the IEPA following consultations with the ISGS and the ISWS.

Some of these aquifers are hydrologically connected and function as hydrostratigraphic units in parts of the State. Among these, best known is the Cambrian-Ordovician aquifer which is primarily comprised of the Ironton-Galesville Sandstones, the Franconia Formation, the Eminence-Potosi Dolomites, the Prairie du Chien Dolomites, the Glenwood-St. Peter Sandstones, and the Galena-Platteville Dolomites in northern Illinois (Suter et al., 1959; Technical Advisory Committee on Water Resources, 1967). However, the IEPA used individual aquifer designations due to variations in aquifer properties over a statewide basis.

Table 1. Aquifers of Illinois

Name of aquifer	General Lithology
Quaternary	sands & gravels**
Cretaceous-Tertiary	sands & gravels**
Pennsylvanian	sandstones, limestones, & coals**
Chesterian	sandstones & limestones**
Valmeyeran	limestones & sandstones
Silurian-Devonian	dolomites & limestones
Maquoketa*	dolomites & fractured shales**
Galena-Platteville	dolomites & limestones
Glenwood-St. Peter	sandstones
Prairie du Chien*	dolomites & sandstones
Eminence-Potosi	dolomites
Franconia*	sandy dolomites
Ironton-Galesville	sandstones
Elmhurst-Mt. Simon	sandstones

*Considered of minor importance, refer to text for details.

**Rock types listed may be water yielding but generally make up less than half of the total rock thickness in the indicated unit.

Groundwater Movement

Ground water is found in two basic types of aquifers. Unconfined (water table) aquifers occur when the water in the aquifer has a surface which is free to respond to changes in atmospheric pressure. A confined (artesian) aquifer occurs when an aquifer is bounded above and below by impermeable or distinctly less permeable beds than of the aquifer itself.

In shallow aquifers ground water moves from a point of recharge to an area where water levels have been lowered by discharge. This movement is the result of hydraulic head (gravity). Little is known about groundwater flow in the deep aquifers of the Illinois Basin. Density stratification of ground water occurs in these aquifers in which flow is not a simple function of the hydraulic head (Bond, 1972). Although the general flow direction is lateral within an aquifer, vertical flow (upward or downward) takes place between aquifers depending on the difference of their hydraulic heads.

Precipitation falling upland areas will partly be discharged into streams and partly infiltrate downward to recharge the Quaternary and shallow bedrock aquifers. These bedrock aquifers include the Galena-Platteville, the Glenwood-St. Peter, the Prairie du Chien, Silurian carbonates and probably the Cambrian age aquifers in northern Illinois; the Cretaceous-Tertiary, the Valmeyeran, the Chesterian, and the Silurian-Devonian in western and southern Illinois; and the Pennsylvanian sandstones and limestones in the southern two thirds of the State. Where the uppermost bedrock is shale or dense dolomite, as in the Pennsylvanian System, the New Albany and the Maquoketa Groups, groundwater flow is more complex due to the relatively low hydraulic

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conductivities of shale and dense dolomite. Some infiltration may enter through vertical joints and fissures and recharge lower aquifers. However, these relatively less permeable confining beds generally impede groundwater flow and partially prevent recharge to the underlying aquifers.

The bedrock aquifers are mostly recharged in northern and western Illinois where they outcrop or immediately underlie the Quaternary deposits. Some recharge may also occur vertically through overlying formations. Ground water generally flows within the bedrock aquifers to the south and southeast towards the center of the Illinois Basin and flushes out brine in deeper aquifers (Bond, 1972). The flushing is very slow and incomplete (Plate 6).

Studying temperature anomalies of rocks, Cartwright (1970) postulated that within a 100-mile radius from the center of the Illinois Basin, ground water is discharged upward through fracture zones associated with anticlines and fault zones. Examining hydrodynamics of the deep aquifers (the St. Peter Sandstone and deeper), Bond (1972) postulated (1) in the Mt. Simon aquifer, ground water flows from west to east in the northern third of Illinois, (2) in the northwestern part of Indiana, water flows from the Mt. Simon aquifer up to the Ironton-Galesville aquifer through faults and fractures (3) ground water flows from north and northwest towards the central and western parts of Illinois in the Ironton-Galesville and St. Peter aquifers, (4) prior to pumpage, the vertical hydraulic head differences in the deep aquifers of the Illinois Basin were scarcely large enough for upward flow of water through an open conduit(s) and (5) if any flow from the Mt. Simon to the

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Ironton-Galesville and to the St. Peter occurs in the central part of the Basin, this flow may happen through fractures in confining beds. The last conclusion is not in conformance with those of Graff et al. (1965, 1966) and Bredehoeft et al., (1963) who postulated that some water is discharged upward through clay shales which function as osmotic membranes.

Groundwater Quality

Water containing less than 1,000 mg/l TDS is considered suitable for beneficial uses (IPCB, 1979). When better quality water is not available, water containing more than 1,000 mg/l TDS is also used. Normally, the quality of water in the aquifers of the Quaternary and the Cretaceous-Tertiary is suitable for beneficial uses.

All the bedrock aquifers contain both useable water, underground source of drinking water (USDW), and non-useable water, underground source of nondrinking water (USNDW). Bedrock aquifers contain usable water along the western periphery of the Illinois Basin, where they outcrop or subcrop under the Quaternary deposits. Furthermore, in much of the northern third of Illinois bedrock aquifers contain useable water. In general, the TDS content of water in bedrock aquifers increases towards the south within the Illinois Basin, and with depth.

Hydrogeology of Illinois Rocks

In the following pages, the properties of the aquifers and the confining layers in the State will be described, parts of the aquifers which are an USDW and an USNDW will be identified, and ground water quality of the aquifers will be described.

impermeable unit (Suter et al., 1959). Walton (1965) states the lowest rate of recharge of water to the Cambrian-Ordovician aquifers occurs where the Maquoketa is present, and the average coefficient of vertical hydraulic conductivity the Maquoketa is 0.00005 gpd/sq ft. However, dolomite beds in the middle unit are known to yield small quantities of ground water in the Chicago region (Suter et al., 1959), where the Maquoketa is considered a minor aquifer.

The Maquoketa aquifer is used independently of the Silurian-Devonian aquifer by PWS in three northern Illinois counties completed in the ISWS Bulletin 60 series: Kane, Kendall, and Mc Henry. The TDS content of water from the Maquoketa aquifer in these three counties ranged between 212 mg/l in Mc Henry County (Woller and Sanderson, 1976a), and 572 mg/l in Kane County (Woller and Sanderson, 1978c). The Maquoketa was used in combination with the Silurian-Devonian aquifer in Lake and Mc Henry Counties.

The Maquoketa Group is known to yield water to wells only in northeastern Illinois. Because the Maquoketa Group is considered to be a caprock in central Illinois, an area where the formation waters may contain more than 10,000 mg/l is not illustrated on Plates 22 and 23. The 10,000 mg/l TDS boundary would fall between similar boundaries in Silurian-Devonian and Galena-Platteville aquifers (Brower, 1980, personal communication).

Silurian-Devonian (Hunton Megagroup): Aquifer. The Hunton Limestone Megagroup comprises dominantly carbonate rocks of Silurian and Devonian age that are stratigraphically positioned between the rocks of the Late Ordovician (Maquoketa Shale Group) and the Late Devonian (New Albany

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Shale Group) (Willman et al., 1975). Hunton strata underlie most of Illinois, except where eroded in north-central, extreme north-western, and small areas in the western and southern parts of the State (Plates 24 and 25). The Megagroup thickens to over 1800 feet in southeastern part of Illinois (Plate 25). It is almost entirely dolomite in the northern half of Illinois and limestone in the southern half.

The Silurian System includes three Series. The lower two, the Alexandrian and the Niagaran, are widespread but the uppermost, the Cayugan Series, is present only in southern Illinois (Plates 2 and 3). The Silurian rocks are overlain by glacial drift in northwestern and northeastern Illinois. They crop out in bluffs of several rivers including the Des Plaines, Kankakee, Fox, Mississippi, and Illinois. Several outcrops and subcrops occur in southern Illinois. The Alexandrian rocks (at the base) are generally argillaceous limestone or dolomite, overlain by purer glauconitic limestone or dolomite which is very cherty in some areas. The overlying Niagaran Series consists of three facies, a dominantly shaly facies in the south, a facies of intermediately pure dolomite extending from western Illinois to the Chicago region, and a relatively purer dolomite facies in northwestern Illinois. All three facies contain some reefs.

The Silurian strata are overlain by Devonian rocks; however, these are absent in northern Illinois (Plates 2 and 5). Where present, the Lower Devonian rocks are dominantly siliceous limestone, dolomite, and chert. The Middle Devonian is largely pure limestone and dolomite.

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The structure on top of the Silurian-Devonian carbonates (Hunton) is shown on Plate 24. Where overlain by the New Albany Shale Group, the elevation of the Silurian-Devonian ranges between 400 feet above msl in northern Illinois and 5000 feet below msl in the deeper part of the Illinois Basin.

Numerous joints and other crevices ranging in size from hairline cracks to caverns are present within the Silurian rocks in northern Illinois. These water-yielding openings are irregulary distributed and interconnected on an areal basis, producing inconsistent yields to wells. Most PWS wells which open to this aquifer are located in northeastern and northwestern Illinois and obtain water from only Silurian Dolomites (Piskin et al., 1981). The Niagaran and Alexandrian Series have about the same average productivity in areas where the units are the uppermost bedrock (Csallany and Walton, 1963). A study was made of the specific capacities of municipal and industrial supply wells in the Silurian Dolomite in Lake, Du Page and Will Counties (Suter et al., 1959). Wells in Du Page County had the highest average specific capacity (54.5 gpm/ft), and wells in Lake County had the lowest average specific capacity (5.0 gpm/ft). The coefficient of transmissivity averaged about 9,000 gpd/ft in Lake County, 24,000 gpd/ft in Will County, and 52,000 gpd/ft in Du Page County.

Silurian rocks are well known for their variable yields in different locations. Csallany and Walton (1963) reported that the adjusted specific capacities of Silurian wells ranged from a high of 404.0 gpm/ft in Whiteside County to a low of .63 gpm/ft in Rock Island County. Based on data reported by them, the estimated average specific capacities of Silurian wells in northern Illinois, outside of the Chicago area, is approximately 10 gpm/ft. They concluded, based on similar geologic conditions, the productivity of Silurian wells is about the same in northwestern Illinois as it is in northeastern Illinois.

Throughout northern Illinois the productivity of the Silurian is reduced where overlain by bedrock. Where Silurian rocks are beneath Pennsylvanian, Mississippian, or Devonian rocks, the productivity of the Silurian is lowered to about the same magnitude as the Maquoketa rocks of northeastern Illinois (Csallany and Walton, 1963).

Specific capacities of wells open to both Devonian and Silurian rocks indicate the Devonian of northern Illinois contributes very little water to wells. However, the Devonian is known to be porous and permeable in the Illinois Basin. The Devonian-Silurian-Galena-Platteville carbonate reservoirs in Illinois' oil fields have a mean porosity and permeability reported at 13 percent and 40 millidarcys, respectively (Bergstrom, 1968). Data from water injection wells located in the Illinois Basin indicate that Devonian limestones have a porosity and permeability that range from 12.0 to 16.8 percent and 50 to 300 millidarcys, respectively (Ford et al., 1981). The Devonian Limestone is also a source of ground water in southern Illinois. In Pulaski County, PWS well yields of over 300 gpm are obtained from the Devonian rocks (Woller and Sanderson, 1978d).

The Silurian-Devonian aquifer is a source of ground water in seven counties completed in Bulletin 60 series reports: Ford, Kane, Lake, Mc Henry, Pulaski, Stark, and Warren. The TDS content of water from the Silurian-Devonian aquifer in these counties ranged between 230 mg/l in

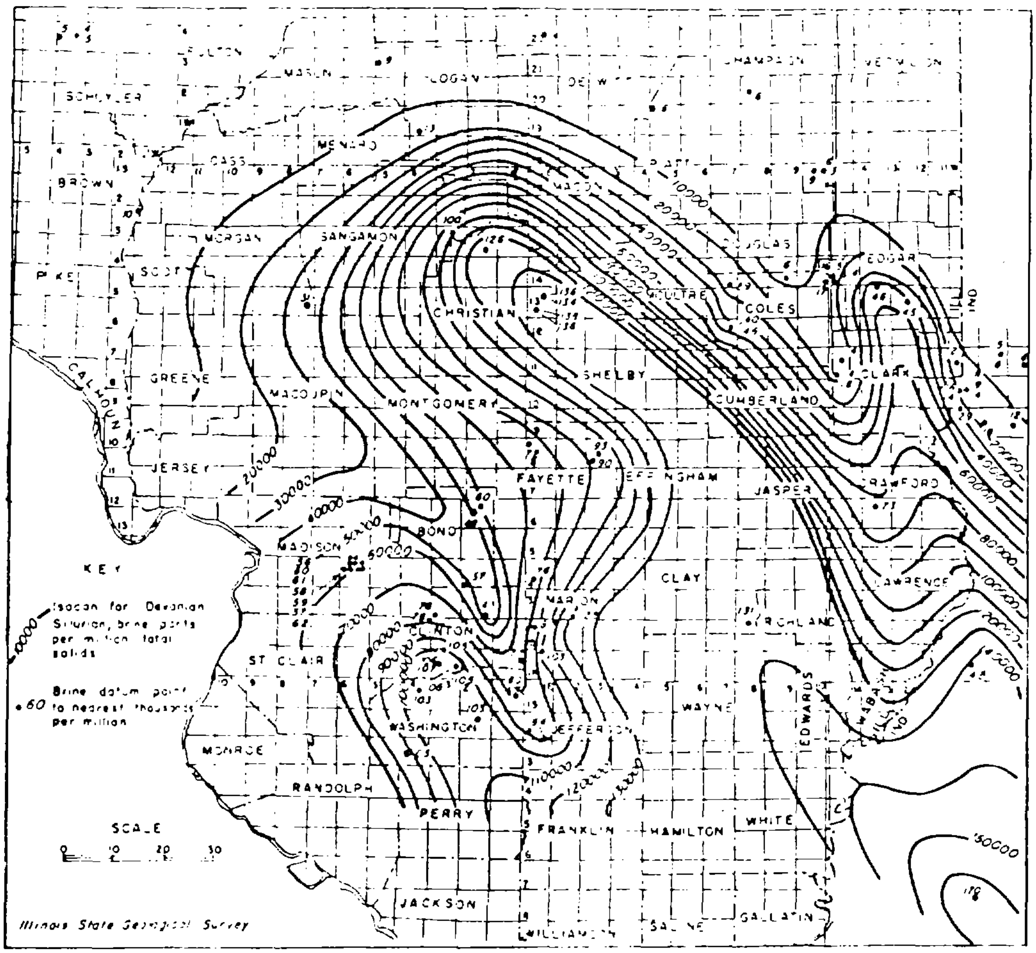

Figure 6. Concentration of total dissolved solids in water from the Silurian-Devonian carbonates of southern Illinois (after Meents et al., 1952).

Lake County (Woller and Gibb, 1976) and 1,900 mg/l in Stark County (Woller and Gibb, 1975b). Water quality for the Maquoketa Group was included with TDS data for the Silurian-Devonian aquifer in Lake and Mc Henry Counties.

The approximate boundary of water in the Silurian-Devonian containing more than 10,000 mg/l TDS is shown in Plates 24 and 25. Figure 6 illustrates the approximate location of water in the Silurian-Devonian containing over 10,000 ppm TDS (Meents et al., 1952). The TDS lines on both maps are very similar. Water with less than 10,000 mg/l TDS is found in the northern half of Illinois and extreme southwestern Illinois. Outcrop and subcrop areas in Union, Alexander, and Pulaski Counties coincide with areas where the Silurian-Devonian aquifer contains water with less than 10,000 mg/l TDS.

The highest TDS concentration in water from the Silurian-Devonian aquifer (Figure 6) occurs in Edwards, Wabash, Wayne, and White Counties, where the aquifer is believed to contain more than 140,000 ppm TDS. Information from Graf and others (1966) indicates water within the Devonian aquifers reaches a TDS concentration of 216,100 mg/l, approximately 5,365 feet below the surface in Wayne County. Also water in the Silurian aquifer, around 1,950 feet below ground in Macon County, has a TDS concentration of 139,000 mg/l.

New Albany: Confining Bed. The New Albany Shale Group (Willman et al., 1975) consists of an essentially continuous body of Middle Devonian, Upper Devonian and Kinderhookian (lower Mississippian) black, gray, and green shales (Plates 2 and 3). The Group has a maximum thickness of about 400 feet. The New Albany Shale is present in most of the southern